AN EVALUATION OF SPATIAL EQUILIBRIUM MODELS FOR POLICY DECISIONS IN THE DAIRY INDUSTRY

by

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INTRODUCTION

Voters in the United States both urban and rural are concerned about our agricultural policies. This general concern exists because economic questions are involved. To the urban people the expense of support programs and surplus commodities cause unrest. To the farmer the inequity of his income and the instability of farm commodity prices cause him to be gravely concerned.

Due to this social concern and national interest, significant questions are being asked about the present agricultural policies and programs. Supposedly the purpose of these policies and programs is to change the existing supply and demand structure into one which will hopefully provide a desired level of production, stability of agricultural product prices, and equity of incomes for farmers. However, farm incomes continue to lag those of urban dwellers. Hourly earnings in farming have not risen relative to increased output per man hour nearly as much as have nonfarm earnings. Individual farmer's self-interest often seems in conflict with group interest. If not solved, these problems will continually jeopardize the agricultural sector.

Before policies controlling agriculture can be effective and workable, a nation must have sufficient knowledge of the relevant relationships of demand and supply. A clear understanding of the laws of price equilibrium and price response is necessary if American agriculture is to operate in the public interest. This does not necessarily mean a withdrawal of government from all of the places where it now plays a

part in supporting farm prices, but it means a much better foundation is needed for making future policies more successful.

Because these farm programs have consequences that affect the national interest, significant questions are being asked. In the dairy sector questions concerning the allocation of resources, distribution of incomes and equity of incomes between farm and nonfarm sectors, for example, are typical. Economists can be involved in the solution of such problems. They can structure analytical models that are useful in analyzing changes in government policy. Such models can be relevant to the private as well as the public policy maker. Their value rests with the capability of such models to predict the consequences that would result from new or revised agricultural policies or continuance of existing policies.

PROBLEM SETTING AND OBJECTIVES

Farmers are uneasy with national dairy policies. Price, and hence incomes, received by dairy farmers are greatly influenced by government price policies and programs. Prices for milk eligible for fluid use are directly or indirectly related to federal milk marketing order programs. At the same time, prices paid for manufacturing grade milk are supported through governmental purchases of butter, cheese, and nonfat dried milk at specified prices. While these two programs are carried out under the auspices of different statutes, their impact on milk markets is not independent.

Legislative acts such as the Agricultural Marketing Agreement Act of 1937 must, of necessity, be general in their statements of intent and procedures. The agency that administers such legislation must be allowed enough freedom to cope with the unforeseen and to develop the mechanics and administrative procedures best suited for effectuating the policy of the legislation it administers. But as is sometimes the case in legislative documents, the various statements of objectives and intent are not completely compatible with each other. This places a burden on the Secretary of Agriculture and his agents of interpreting and assigning priorities to the various statements.

Early interpretations of the Federal Order Program were aligned with enhancement of dairy farmer's income. The parity concept was used as the standard for establishing prices. Little regard was given to supply-demand relationships. Beginning in the early 1940's the

supply-demand concept received increasing emphasis. Today the basic standard used to establish the level of Class I prices under this objective is the concept of equating milk supplies with consumption. When supplies become excessive relative to consumption, the supply-demand standard calls for lower prices and vice versa. This concept has been affecting the level of Federal Order prices both at the national level and the individual market level.

At the national level, the value of manufacturing milk varies according to the dairy industry supply-demand situation. In all but a few markets where prices are established by economic type formula, Class I prices are obtained by adding a differential to a basic formula price that reflects the value of milk used for manufactured milk products. Thus, the national supply-demand conditions for milk affect the level of Class I price.

At the individual market level, the concept of equating milk supplies with consumption takes the form of supply-demand adjustors which modify the amount of the Class I differential added to the manufacturing milk values. This is highly affected by the seasonal variation in milk production.

Although prices are established for individual markets, there is a great deal of interdependence among markets. The decisions of the Secretary of Agriculture regarding prices have increasingly reflected this interdependence. The attempts to balance supply and demand in individual markets with supply-demand adjustors have created problems in the alignment of prices among markets. Thus, the supply-demand concept has been shifting from a market by market basis toward a regional

or broader basis.

Under the supply-demand standard, the supply function has only two variables: price and quantity. However, there are other variables in the supply function as well as price that are important from the policy standpoint. One example would be technology. Knowledge about supply functions and their behavior has increased over time, but the truly relevant variables in supply functions seem still to be discovered, or at least to be placed in the proper relationship with one another.

A central problem is that location theory does not adequately explain the tremendous buildup of Grade A milk supplies and the resulting surplus problem. Policy makers, both public and private, need an analytical device which will reliably depict the consequences of any changes made in farm policies. This model must be general enough to apply to the national dairy market, but specific enough to depict the impact of changes in policies on the regional and local level as well. Thus, this model must be carefully and rigidly defined and must include all relevant variables.

For example, regions should be used to define markets. Since the regions will be and are continually subjected to changing technology and changing structure of the dairy firms, they must be rigidly defined aggregatively.

Objectives

Given the above problem situation, the objectives of this study are:

(1) To critically appraise the state of knowledge about spatial equilibrium models as useful econometric devices for policy

planning in the private and public sectors.

(2) To develop extensions of relevant spatial models to improve their usefulness in analyzing the impact of changes made in Federal Order policies on the national market as well as on regional markets.

REVIEW OF LOCATION AND SPATIAL MODELS

Several studies have been made in which location and spatial models were developed and discussed. These studies range over a great length of time in history and present a classical approach in dealing with factors and products in space.

Location Models

The first known attempt to analyze the effects of space on economic activity was made by a German, J. H. Von Thunen,[1] in 1826. His theory basically began with an explanation of location of various productive activities in an isolated city-state with a land area having homogeneous resources; bulky and perishable goods were produced near the city, while concentrated and durable products were drawn from more remote points. Von Thunen had four basic assumptions: (1) a town is located in the center of a fertile plain bordered by a wilderness, (2) all land between the central market and the unexplored periphery is of homogeneous quality, (3) there are no obstacles to, or special facilities for, transportation which would give some of the cultivated land a locational advantage over other cultivated land, and (4) there is no trade with the "outside" world.[2]

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[1] Johann Heinrich Von Thunen, The Isolated State in Relation to Agriculture and Political Economy, Translated by Carla M. Wartenberg and Edited by Peter Hall (London: Pergamon Press, 1966).

[2] Ibid., p. 7.

A pictoral representation of his isolated state is given in Figure 1.[3]

Although his scheme of concentric circles around a central town was not fully applicable to all industrial locations, von Thunen's theory was nevertheless useful. It afforded a point of departure for more advanced analysis, and it emphasized the noninstitutional factors of location. Von Thunen's formulation revolved around the cost of transportation and the rent of land, which together explained why a particular agricultural product was grown on a given plot of land. Farm produce was sold in each outlying region at the city or consuming center price less the difference in the cost of transport to that region and the city. Thus, moving farther away from the consuming center caused the transportation costs to the city to increase. On the other hand, land rent, the intensity of land cultivation, and the density of the population decreased the farther away the location was from the city. The capital factor had no place in von Thunen's theory because he assumed a homogeneous land surface and complete mobility of capital.[4]

Von Thunen was primarily interested in the type of farm produce which was most advantageously cultivated on a given plot of land. The theory which he derived from this objective and the aforementioned assumptions was, therefore, essentially an explanation of location of agricultural commodities.

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[3] Ibid.

[4] Melvin S. Greenhut, Plant Location in Theory and in Practice (Chapel Hill: The University of North Carolina Press, 1956), p. 6.

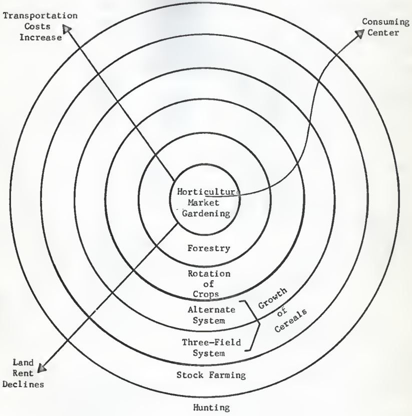

Figure 1. Von Thunen's isolated state and land use patterns.

Some 83 years elapsed before the second major work in this area was published, again in Germany, by Alfred Weber.[5] Weber's theory of location was procedurally the opposite of von Thunen's. In von Thunen's theory, the location was given and the type of production was to be determined; in Weber's theory, the branch of industry was given and the place of location sought.

Weber's theory was based upon three general factors of location: transportation cost, labor cost, and agglomerating forces. He elaborated the theory to include uneven distribution of resources. Thus factories were so located that the summed costs of assembling raw materials and distributing finished goods were minimized.

The vital point in Weber's breakdown of location factors was his exclusion of institutional and special factors. Interest, insurance, taxes, and other similar forces were regarded by Weber as institutional factors. Therefore, he excluded them from a general "pure theory" of location, and accepted only those forces which were independent of specific economic systems.

Basically, Weber's theory of location involved substitution between transport cost and non-transport cost factors. In his theoretical system, a series of isodapanes were placed around the minimum transfer cost point, with the curve farthest away from the minimum isodapane representing sites having the highest transfer burdens.[6] If one of

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[5] Alfred Weber, Theory of the Location of Industries, Translated by C. J. Friedrich (Chicago: University of Chicago Press, 1928).

[6] Greenhut, op. cit., p. 12. An isodapane is defined by Greenhut as a point of equal transfer cost.

these isodapanes exceeded the least-cost transfer point by an amount equal to the non-transfer cost economies obtainable at an alternative point, this curve was the critical isodapane. If the alternative production point lay inside this curve, the production advantage was more than worth the difference in transfer cost. If it lay outside the critical isodapane, the economy in production was less than the extra transfer cost than would be entailed in the shift. Each location had certain transfer cost advantages or disadvantages when compared to other locations, and similarly non-transfer cost advantages or disadvantages.[7]

Figure 2 below illustrates Weber's theory of location in terms of two factors: the transport and non-transport factors. This figure was used to depict the cost substitutions which took place in the search for the least-cost site. The least-cost point represented minimization of expense of shipping raw materials and finished products as well as fuel and raw materials cost at given sites, as compared to the non-transport costs of land and labor.[8]

A movement up the vertical axis or a movement to the right on the horizontal axis indicates increasing costs.

The curve of substitution SS is an isosale curve connecting a series of locations at which equal number of units may be sold at the equilibrium price. This isosale curve assumes the long-run position where each firm is identical in size and sells the same number of units of finished product.

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[7] Ibid., pp. 12-13.

[8] Ibid., p. 13.

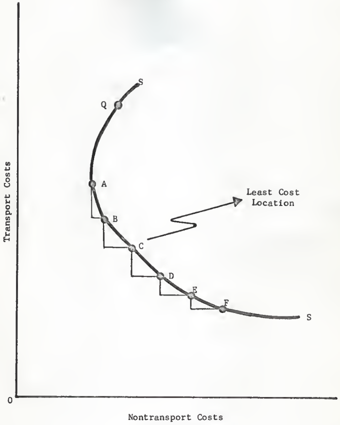

Figure 2. Weber's theory of location as represented by an isosale curve (SS) and a series of isodapanes.

The isosale curve is less elastic from points C to A and more elastic from C to F. A movement from point B to A indicates a small saving in non-transport cost but a larger increase in transportation cost. A shift from D to F results in an accelerating decrease in transportation cost but a more than offsetting increase in the non-transfer expenses. Point C on the curve of substitution is the least-cost location of transport and non-transport costs. It is the point of unitary elasticity.

While generally some costs increase and others decrease at different sites, there are locations at which all costs are lower. Thus, an entrepreneur may realize savings not only in transport cost but also in non-transport cost by locating at A as compared to Q. This situation modifies the traditional explanation of factor adjustments; it does not destroy the framework.[9]

Other basic location studies and theories were written by Ohlin (1933),[10] Hoover (1937),[11] Losch (1954),[12] and Isard (1956).[13] In these more contemporary writings, much attention was given to determination of borders of raw material supply areas and product distribution areas.

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[9] Ibid., pp. 15-16.

[10] Bertil Ohlin, Interregional and International Trade (Cambridge: Harvard University Press, 1933).

[11] Edgar M. Hoover, Jr., Location Theory and the Shoe and Leather Industries (Cambridge: Harvard University Press, 1937).

[12] August Losch, The Economics of Location, Second Ed. revised, Translated by W. H. Woglon (New Haven: Yale University Press, 1954).

[13] Walter Isard, Location and Space Economy (New York: The Technological Press of the Massachusetts Institute of Technology and John Wiley and Sons, Inc., 1956).

Emphasis was also placed upon the role of transportation costs in markets having numerous competing firms.

In Ohlin's book, general theories of interregional and international trade drawn from the fields of price theory and location economics were developed and analyzed. The foundation was the mutual interdependence theory of pricing. Specific attention was given to the mechanism of variations in international trade and capital movements.

Hoover extended the general theory of location by combining existing theory with the firm theory and partial equilibrium analysis. This combination was employed to analyze the past and present location of the leather and shoe industries.

Losch integrated Walrasian general equilibrium theory and location theory to create a general system of analysis. Location was chosen in terms of spatial interdependence, assuming (1) a continuous transport plane, (2) uniformly distributed population, (3) cost relations rather than production functions, and (4) commodity prices that depend only on demand.

Isard developed a general theory of location and space-economy in an effort to improve the spatial and regional frameworks of economic analyses. The theory derived its general location principles by synthesizing and reducing to common terms the many early location theories.

Due to the complexity of spatial economic relationships, the testing of these early theories awaited the development of computers and sophisticated algorithms.

Other contributions to this general area were made by Koopmans,[14] Dantzig,[15] and others in developing the activity analysis model of production and allocation, and by Leontief[16] in developing the input-output technique for general equilibrium analysis.

Conceptual Framework of Spatial Models

With the objective of specifying a conceptual framework and the design of the corresponding operational model, Enke,[17] Samuelson,[18] Beckmann,[19] and Baumol[20] have been quite instrumental in setting out the problem of interconnected competitive markets in a new form, while at the same time opening a new approach to spatial pricing systems and competitive locational equilibrium. This new operational formulation permitted space to be treated explicitly and presented the rationale whereby a purely descriptive problem in nonnormative economics can be

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[14] T. C. Koopmans, "Optimum Utilization of the Transport System," Econometrica, XVII, Supplement (July, 1949), pp. 136-146.

[15] G. B. Dantzig, "Application of the Simplex Method to a Transportation Problem," Cowles Commission Monograph 13 (New York: John Wiley and Sons), pp. 357-374.

[16] W. W. Leontief, Studies in the Structure of the American Economy (New York: Oxford University Press, 1953).

[17] Stephen Enke, "Equilibrium Among Spatially Separated Markets: Solution by Electric Analogue," Econometrica, XIX (January, 1951), pp. 40-47.

[18] Paul A. Samuelson, Foundation of Economic Analysis (Cambridge: Harvard University Press, 1947).

[19] Martin J. Beckmann, "A Continuous Model of Transportation," Econometrica, XX, No. 4 (October, 1952), pp. 643-660.

[20] William J. Baumol, "Spatial Equilibrium with Supply Points Separated from Markets with Supplies Predetermined," Ditto Report, Bureau of Agricultural Economics, U.S.D.A., Washington, D.C., 1952.

converted into an extremum problem in which linear programming can be employed as a tool of analysis. By converting the spatial equilibrium system into an extremum problem, insights can be obtained relative to the geographic location of production, spatial equilibrium prices and the optimum geographical flows consistent with a given set of data.

The general problem of equilibrium among spatially separated markets has been stated in one of its simplest forms by Enke. His formulation proceeded as follows:

> There are three (or more) regions trading a homogeneous good. Each region constitutes a single and distinct market. The regions of each possible pair of regions are separated--but not isolated--by a transportation cost per physical unit which is independent of volume shipped. There are no legal restrictions to limit the actions of the profit-seeking traders in each region. For each region, the functions which relate local production and local use to local price are known, and, consequently, the magnitude of the difference which will be exported or imported at each local price is also known. Given these trade functions and transportation costs, we wish to ascertain: (1) the net price in each region; (2) the quantity of exports or imports for each region; (3) which regions import, export, or do neither; (4) the aggregate trade in each commodity; (5) the volume and direction of trade between each possible pair of regions . . .[21]

Enke then suggests how a solution to this problem may be obtained by electric analogue.

Samuelson has demonstrated how the Enke problem contains within it the following Koopman's-Hitchcock minimum transportation cost problem:

> A specified number of (empty or ballast) ships is to be sent out from each of a number of ports. They are to be allocated among a number of other receiving ports, with the total sent in to each such port being specified. If we are given the unit costs of shipments between every two ports, how can we minimize the total cost of the program?[22]

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[21] Enke, op. cit., p. 41.

[22] Paul A. Samuelson, "Spatial Price Equilibrium and Linear Programming," American Economic Review, XLII (June, 1952), p. 284.

It should be noted that the Koopman's-Hitchcock problem implicitly assumed that the scale of output and the demand in each region were known.

Samuelson has investigated the many-region location problem posed by Enke, and has suggested how it can be placed mathematically into a maximum problem which can be solved by trial and error or by a systematic procedure of varying shipments in the direction of increasing the social payoff.

Takayama and Judge[23] gave a restatement of the Samuelson formulation which represented quite well the concept of social payoff.

Graphically, they represented the formulation as in Figure 3 below.[24]

Social payoff in any region was defined as the algebraic area under the excess demand curve.[25] This was equal in magnitude to the area under the excess supply curve but with the opposite algebraic sign. Net social payoff for all regions was defined by Samuelson as the sum of the n separate payoffs minus the total transport costs of all shipments.

In the figure, D_1, D_2, S_1, and S_2 are regional demand and supply functions. E_{s_1} and E_{s_2} are regional excess supply functions, and T_{12} is the transportation cost per unit between regions 1 and 2. In this figure net social payoff is the area $\hat{P}_2 CF \hat{P}_1$ minus $\bar{P}_2$ C F $\bar{P}_1$. Therefore,

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[23]T. Takayama and G. G. Judge, "Spatial Equilibrium and Quadratic Programming," Journal of Farm Economics, XLVI (February, 1964), pp. 67-93.

[24]Ibid., p. 71.

[25]Samuelson, op. cit., pp. 287-292.

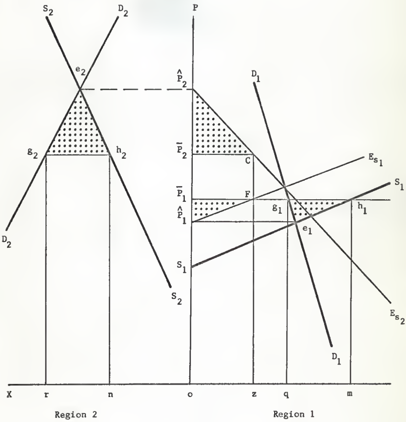

Figure 3. Formulation of social payoff.

net social payoff is $\Delta \hat{P}_2 C \bar{P}_2 + \Delta \bar{P}_1 F \hat{P}_1$ which is equal to $\Delta e_2 g_2 h_2 + \Delta e_1 g_1 h_1$. When net social payoff is the maximum, P_1 and P_2 are the competitive equilibrium prices and $0 Z = q m = r n$ is the equilibrium flow from region 1 to 2.

Expanding this formulation to an n region one product case followed quite easily from this framework as Takayama and Judge showed in their work.[26]

Baumol[27] has presented a solution similar to that of Samuelson. Beckmann[28] has extended the formulation and has considered the case of continuous geographical intensity distributions of production where every infinitesimally small area in an economy both produced and consumed a given commodity. The problem minimized total transportation costs of a commodity flow subject to a given program of production. The solution yielded the optimum flow and the efficient price structure in a competitive spatial market, given the required data on production, consumption, and transportation costs. A necessary condition for the solution of the problem was obtained by using the Lagrangean multiplier. Beckmann's approach was quite rigorous but he did put forth some concepts that were beneficial to location and spatial theory.

Under all of these formulations, theoretically, both the geographic distribution of production and consumption and the optimum geographical pattern of interregional flows were derived simultaneously.

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[26] Takayama and Judge, op. cit., p. 79.

[27] Baumol, op. cit.

[28] Beckmann, op. cit.

Although these formulations ignored a number of basic locational forces, if a finite number of production and consumption points or regions were specified, the Enke-Samuelson-Beckmann models offered an efficient approach to spatial pricing systems and the determination of the resulting geographical flows of commodities.

Recent Conceptual Models

None of the previous models introduced time into their analyses. Introducing the time dimension into the model opens the way to handling many of the difficult problems concerned with price adjustment and allocation over time when products can be stored and the products between time periods are considered substitutes in consumption.

A recent model has been postulated by Takayama and Judge[29] built on the Samuelson concept of net social payoff. In addition to the space dimension, their general formulation has been written so that many questions concerning the time dimension can be attacked. They restricted their presentation to a single commodity specification, but noted that extension to the multicommodity dimension was straightforward given the initial formulation. After setting up the intertemporal model, Takayama and Judge converted it into a quadratic programming problem, thereby making it possible to solve the model by computer analysis.

Even before Takayama and Judge wrote their article on the time

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[29] T. Takayama and G. G. Judge, "An Intertemporal Price Equilibrium Model," Journal of Farm Economics, XLVI, No. 2 (May, 1964), pp. 477-484.

dimension model, Hassler[30] wrote an article which developed three models. These models minimized transportation costs using space, form, and time as explicit variables. He also suggested other more complex models using different demand and supply conditions. Hassler discussed the use of interregional competition models for establishing economic efficiency, for description, and most importantly, for prediction.

A quote from Hassler seems appropriate at this point:

> One could say that demand and supply are the determinants of the economics of interregional competition in agriculture. As with most general statements, it would be a valid proposition, but of little practical value. Much more detail about the multiple components of these two forces would be required before an operationally useable structure could be developed for study and appraisal purposes. The basic framework must be constructed in the space, form, and time dimensions with meaningful criteria underlying the decisions of the human agents involved. The construction of theoretical economic models must compromise between a meaningful degree of realistic detail and the unmanageable quantification problem resulting with increasing complexity. This places a major burden on the research worker--the selection of the most significant components for inclusion in his formulation. A large amount of oversimplification is inevitable.[31]

A completely knowledgeable critique of these intertemporal models is impossible due to the fact that they have not been empirically tested.

However, even after empirical testing, it is difficult to judge the reliability of a spatial model. Since a typical spatial model predicts a number of variables such as interregional flows, regional prices, production, and so on, depending on the objectives of the particular study, it is difficult to make an assessment of a model's overall

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[30] James B. Hassler, "Interregional Competition in Agriculture: Principal Forces, Normative Models, and Reality," Journal of Farm Economics, XLI, No. 5 (December, 1959), pp. 959-968.

[31] Ibid., p. 959.

predictive ability. Much of the empirical work done to date in certain areas may lack a specific purpose. If the question that promotes the research relates to a specific variable, the research should be keyed on that variable. Reliability of the model should be based upon how well the key variable is predicted.[32]

There are a number of conceptual issues and problems in using spatial equilibrium as a methodology, and these will be discussed in the next section.

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[32]Thomas D. Wallace, "The General Problem of Spatial Equilibrium: A Methodological Issue," Printed in Interregional Competition Research Methods (Raleigh: The Agricultural Policy Institute, North Carolina State, 1964), pp. 11-17.

CONCEPTUAL AND EMPIRICAL ISSUES AND PROBLEMS OF

SPATIAL EQUILIBRIUM METHODOLOGY

When constructing a model using a particular methodology, one encounters both conceptual and empirical problems that need further discussion. Some of the more strategic issues are covered in this section.

Positive vs Normative Models

A conceptual and empirical issue of long-term standing is the importance of problems and limitations of using normative as opposed to positive and predictive models in policy analysis. The issue was discussed at a research methods workshop held at Raleigh, North Carolina. King summarized a few thoughts put forth by Bressler in his opening remarks to the workshop:

> In Bressler's opinion our normative answers are a long way from final application. A normative model is basically a diagnostic tool--we use it to find out if the patient has a fever. However, what causes the fever and what changes should be made to stop the fever are not part of the normative model. Institutional arrangements may cause the Boston milk market, for example, to deviate from what the normative model would specify, but for a particular firm the normative model may be very satisfactory indeed. He noted the counterpart in farm management where a few farmers do change and for those the results correspond closely to those of the normative model. Logical (theoretical) tests may be better measures of a good model than is r^2.[33]

Wallace,[34] in the same workshop, also centered on this issue.

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[33] Richard A. King (ed.), Interregional Competition Research Methods (Raleigh: Agricultural Policy Institute, North Carolina State, 1964).

[34] Thomas D. Wallace, op. cit.

He felt that research extended in the normative direction is "scientifically unsatisfying because we give up our only objective measure of the soundness of our models—namely, how well they predict." Wallace also felt that the normative direction of spatial research has taken us away from research that was needed to answer important questions. He pointed out in the end that he did not see a dichotomy of positive and normative applications of the spatial models in which only positive models were useful. He suggested that emphasis should be placed upon asking specific questions of our models so that we may key upon a given variable in determining predictive accuracy.[35]

Pure Competition

In order to analyze the effects of economic forces, the assumption of pure competition has been maintained in spatial research. In this abstraction from the real world situation was included the assumption that a homogeneous product (assume Grade A milk) was produced by farmers. The introduction of two qualities of milk (Grade A milk and manufacturing milk) would not cause appreciable differences in the outcome so long as both qualities of milk were involved in manufacturing the hard products.

It might, however, lead to an under evaluation for excess fluid milk when it was necessary to divert these excess supplies to the manufacturing milk sector. The under evaluation of this portion of Grade A milk may be both in terms of its cost of production and in terms of the quality of the resulting manufactured products.

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[35] Ibid., pp. 11-17.

Thus the assumption of pure competition could break down in such a situation. Relaxing the assumption of pure competition could affect the intermarket price relationships as well as the total supply of Grade A milk. Monopoly or oligopoly in firms serving the consumer market would involve a downward sloping demand curve facing the firm. The firm would operate at a volume other than where the consumer price equals marginal cost. Monopsony or oligopsony in the firms buying from producers would involve an upward sloping producer supply schedule to the firm. Hence, the firm would operate at a point other than that where the farm price equals the value of the marginal product for raw milk. The traditional stated outcome is the existence of monopoly or monopsony profits, or both.

The assumption of pure competition thus may not be appropriate for the problem at hand. Decision-making theory may call for a structure that can be more adequately applied to monopolistic or oligopolistic markets.

Partial Equilibrium Analysis

Partial equilibrium analysis has often been stated as a serious limitation and issue in spatial analysis. Using linear homogeneous production activities does cause some computational and data problems, but in an important sense linearity allows more general quantitative analysis than nonlinear models. Data necessary and problems of computation are even greater limitations in a more general nonlinear or convex programming model. From a conceptual standpoint one can approximate nonlinear production surfaces as closely as one likes by adding more activities.

Analyzing one sector apart from all others in agriculture has a

relative value of specifying predictive situations in a more precise manner. General equilibrium has more value in a national agricultural model.

Defining an Objective Function

A problem always confronting a researcher using programming analysis is the achievement of an appropriate objective function. In policy analysis this problem is bothersome. Solutions to models prescribing allocative efficiency are necessary for designing intelligent policies and programs, but knowledge of all the individual and social costs of making adjustments to these programs is also necessary.

Deciding whether the objective should be to maximize net revenue or minimize production and distribution costs is a problem. In most of the models discussed the objective function was linear and entailed minimization of production and distribution costs.

A current model extension involved an equilibrium analysis which incorporated a quadratic objective function into the model. Under this formulation the product prices, product mix, and levels of production were determined simultaneously as total profits were maximized subject to the usual production constraints and the competitive condition that total revenue minus the costs of production (land rents and the variable cost) was zero.

Using a quadratic function may require simplifications on the supply side of the model in order to obtain solutions. As the limits to the computational capabilities are lessened by increased computer capacity, considerable additional information may be gained as to the quality of our production data and knowledge of demand relations.

Risk and Uncertainty

The assumption of single-valued expectations in linear programming is another issue. The need for refinement is critical because uncertainty generally increases with the length of the production period. This uncertainty is found in many variables such as the price of milk or the price of alternative products.

One possibility is to use dynamic programming of the stochastic variety in conjunction with recursive constraints in order to adjust the model to this uncertainty.

Reformulating the objective function is another way to cope with risk and uncertainty. To maximize profit is not necessarily the only objective available. It is possible that adjusted profit, or some other variable, would represent more adequately the criterion guiding decision makers.

Aggregation Problem

Another research problem, both conceptual and empirical, is the problem of aggregation. Delineating certain areas in a study leads one to the task of solving the aggregation problem. The question of aggregation was described by Heady as follows:

> The question of aggregation in interregional analysis gives rise to two types of problems: conceptual and practical. Relatively, the conceptual problem is simple. More difficult is the practical problem of optimum extent of aggregation over commodities, inputs and regions. Taking regions alone, if the aggregation is too broad, the results have little practical applicability for policy, education or other programs aimed at stimulating or restraining change for particular groups of farms. For example, if aggregation is broad across producing regions, empirical results predicting equilibrium output and prices may show the ith region to specialize on a commodity while the jth region retires from its production. Yet there will likely be some subregions in the first which should (or will) withdraw resources from the commodity, and

> subregions in the second which expand output, even though the larger regions of which they are a part move in the opposite supply direction. On the other hand, if disaggregation is great and a large enough number of regions is specified to provide meaningful analysis, the empirical task of assembling detailed data surpasses available clerical and professional resources; or the number of relationships specified on the model may exceed computing facilities. I consider this problem in balance (i.e., enough regions to provide meaning in policy or decisions for particular groups of farmers but few enough regions to mesh with clerical, computing and other resources) to be one of the major ones of aggregation. Conceptually, we can specify supply and demand relations for each farm in the nation. But the fact that research workers have finite lives and data become out of date prevents us from designing models, assembling data and inverting matrices with this scale of detail. But how few are necessary to conform with time and facilities available for research? To an important extent, this same dichotomy prevails in respect to aggregation over commodities and resources.[36]

The aggregation problem has been widely recognized in the literature, but relatively little work has been done in the direction of suggesting specific criteria or procedures for aggregation for use by a research worker. However, a number of articles have been written by Fisher[37] describing this problem and offering a method to deal with it.

In a recent work, Fisher summarized what he has attempted as follows:

> A theory of how best to aggregate or simplify a given detailed model of simultaneous equations in the reduced form is proposed, assuming that the model is to be used for prediction purpose. Results are obtained for aggregating exogenous or endogenous

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[36] Earl O. Heady, "Aggregation and Related Problems in Models for Analysis of Interregional Competition," Printed in Interregional Competition Research Methods (Raleigh: The Agricultural Policy Institute, North Carolina State, 1964), pp. 129-145.

[37] Walter D. Fisher, "On Grouping for Homogeneity," Journal of the American Statistical Association, LIII (December, 1958), pp. 789-798.

__________, "Estimation in the Linear Decision Model," International Economic Review, III (January, 1962), pp. 1-29.

variables, or both, including the cases where the aggregation is to be in partitioning form, and where variables are to be eliminated from the model. A Bayes decision theory approach is taken.[38]

In any spatial analysis it is necessary to define regional boundaries. Data, computational and time limitations usually require a considerable compromise with respect to the realities of a space-oriented problem.

With the diversification of farming within each state and region, it is no longer sufficient to draw an arbitrary boundary around a number of states for which data are readily available and term the contents a meaningful homogeneous region. If one is to provide detail in interrelationships of, say, the dairy sectors either among themselves or with related sectors such as feed grain, one must be quite cautious about the aggregative approach. Under some investigations, one may be able to aggregate regional demand functions for a commodity into a single national demand function while disaggregating on the producing sectors or supply regions. However, in analysis of interregional competition and equilibrium for Grade A milk production, estimation of consumer demand functions for the separate geographical or locational sectors may be and probably is as equally as important as estimation of the separate producer supply relationships.

Data Problem

One of the most bothersome of problems in an empirical sense is the one of data collection and usage.

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[38]Walter D. Fisher, "Optimal Aggregation in Multi-Equation Prediction Models," Econometrica, XXX (October, 1962), pp. 744-769.

Possible errors in the data used and their effects on various aspects of the solutions may easily bias the results of our research. Especially, errors in the coefficients derived, whether they be cost or yield coefficients, can offset any value that the solutions of the research problem may have to a policy maker.

Another problem area is to determine the level of market restraints over which certain cost coefficients may apply. For example, in dairy production the market delineated may be too small for the cost coefficients applied to that market. A reduction in these restraints and a broadening of the market area may cause the coefficients to be more precise.

Thus, accuracy in market constraints and cost coefficients is quite important to an analysis of milk production capacity. Also important is the incorporation of more regional detail in the models constructed.

One can easily imagine many other problems and difficulties in constructing a spatial equilibrium model, but a few more important ones have been discussed here. A model accounting for all of these problems may be quite demanding in rigor, but it should greatly increase one's understanding of spatial equilibrium and its limitations and contributions.

CONTRIBUTIONS IN USING SPATIAL EQUILIBRIUM MODELS FOR ANALYZING FARM POLICY

Contributions to the theory of spatial equilibrium can basically be analyzed from two standpoints: first, the net addition of pure constructs to the theory. This topic of purely theoretical models has already been presented. Second, the net addition of operationally testable empirical models to the theory. This latter point will be pursued further.

The applications of spatial equilibrium models are numerous and diverse and are constantly growing. Much has been written on specific applications and in evaluation of these applications of spatial equilibrium models. Only some of the more instrumental articles will be mentioned here.

A pioneer in the field of testing the operational feasibility of spatial equilibrium models was Fox.[39] Employing the Enke-Samuelson-Beckmann formulations, Fox developed spatial price equilibrium models of the livestock-feed sector of the economy.

Fox divided the United States into 10 regions and estimated a demand for feed for each region. Using 1947-1950 regional production of feed numbers and prices of livestock and their demand equations, he derived equilibrium consumption, price, and shipments of feed for each

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[39] Karl A. Fox, "A Spatial Equilibrium Model of the Livestock-Feed Economy," Econometrica, XXI (October, 1953), pp. 547-566.

region. The effect of alternative transportation rates and production levels were also considered. Fox recognized the problem of aggregation that existed, but due to computational and data problems, the number of regions had to be limited to ten.

Methodologically, Fox contributed some important conclusions to the theory:

(1) He discovered and proved that spatial equilibrium models were applicable to forecasting on the regional and national level.

(2) He concluded that major oversimplifications in the equilibrium models were the cause of inaccurate results.

(3) In the light of (2) above, he recommended the possibility of dynamic rather than static analysis, and also the possibility of further disaggregation.

With these conclusions and recommendations, Fox's study remained in the limelight of spatial equilibrium analysis.

A few years later Snodgrass and French[40] employed the transportation model to derive optimum geographical flows for the dairy sector of the economy. They developed several models to specify optimum location of production and processing firms and efficient distribution of dairy products. They used an aggregate model to determine the optimum interregional flows of whole milk and the corresponding equilibrium prices for 1953. Consumption projections to 1965 were also considered, as was the

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[40] Milton M. Snodgrass and Charles E. French, Linear Programming Approach to the Study of Interregional Competition in Dairying, Indiana Agricultural Experiment Station Bulletin No. 637, Lafayette, 1958.

establishment of state milk control agencies. This general model was also applied individually to fluid milk, butter, cheese, evaporated milk, and nonfat dry milk solids. A second model minimized transportation and processing costs in determining the location of processing plants, and a third model added production costs to these and specified optimal production location.

Probably the most important characteristic of this study involved the use of a relatively new research technique at that time--linear programming. This study was one of the first ever to apply this technique to one aspect of interregional competition in the United States dairy industry. However, due to the fact that this technique was new, the data used in the study were often not as complete nor as accurate as desired. On the other hand, for illustrative purposes in general, the data were adequate enough to give correct general direction to the analysis. Thus, if the results were interpreted broadly, this study did add positively to the field of research methodology.

Heady and his co-workers (Egbert,[41] Skold,[42] Whittlesey,[43] and

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[41]Alvin C. Egbert and Earl O. Heady, "Regional Adjustments in Grain Production: A Linear Programming Analysis," U.S.D.A., E.R.S., Technical Bulletin 1241, June, 1961.

[42]Melvin Skold and Earl O. Heady, "Projections of U.S. Agricultural Capacity and Interregional Adjustments in Production and Land Use with Spatial Programming Models," Iowa Agricultural and Home Economics Experiment Station Research Bulletin 539, August, 1965.

[43]Norman K. Whittlesey and Earl O. Heady, "Aggregate Economic Effects of Alternative Land Retirement Programs: A Linear Programming Analysis," U.S.D.A., E.R.S., Technical Bulletin 1351, August, 1966.

Brokken[44]) have applied spatial linear programming more recently to the agricultural sector. Although there were important differences in the details of these models they all fell into the class of an activity analysis model involving physical production activities, transportation activities, and pre-assigned regional quantities of various commodity requirements.

These studies were generally extensions of the model popularly referred to as the "Heady-Egbert Model" or the "Iowa State National Model." These extensions which represented refinements in the original model retained the limitations of the original Heady-Egbert model but to a lesser degree. For the most part the limitations in these models related to the problems of oversimplification of production and transportation possibilities, and errors in the coefficients. These problems were discussed in the last section.

One of the major applications of the many versions of the Heady-Egbert model was to the estimation of current and projected production or excess capacity for the major field crops. This procedure seemed particularly appropriate for projection purposes. Trends and prospects for technological change can be examined for each commodity in each area. Projections can be made under a variety of assumptions regarding change in production and demand. Efficiencies of allocation based on regional comparative advantage were also incorporated into estimates of production capacity under these models.

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[44]Ray F. Brokken and Earl O. Heady, "Interregional Adjustments in Crop and Livestock Production in the United States." In process, to be issued as U.S.D.A. Technical Bulletin.

Estimates derived from these models were particularly significant in indicating excess capacity in agriculture as well as in contributing to the maintenance of a steady policy course in regard to agricultural restraints. The implications for adjustments in individual areas suggested by the Heady-Egbert models were probably overstated in some areas and understated in others. However, while one may disagree with the amounts specified for individual regions, the overall implications of competively reorganizing farming were more clearly indicated.

Although the results derived from these models had to be tempered for policy analysis, they nevertheless did provide better insights into model modifications.

One of the current model extensions involved an equilibrium analysis which incorporated a quadratic objective function into the model. The main proponents of this technique were Takayama and Judge.[45]

They realized that optimal adjustments over space were interdependent and that some way must be found for tying the spatial production, distribution, and consumption activities together. One possibility for accomplishing this objective was to use the outcomes of the regional linear programming analysis to develop normative regional supply relations. If these regional supply relations could be represented as linear price dependent functions and the corresponding regional demand relations specified, then a spatial equilibrium model of the Enke-Samuelson type could be developed and estimated. However, from an operational standpoint many practical problems had to be overcome before

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[45]T. Takayama and George Judge, op. cit.

the results of linear programming analyses of representative firms could be used as a basis for equilibrium analysis. Such burdensome problems as variable pricing and aggregation were an example in this instance.

Thus it was shown that when the regional demands for final products were represented by price dependent linear functions, the concept of maximizing net consumer surplus could be employed to deduce the price condition of spatial equilibrium and the general model could be formulated as a quadratic programming problem. The main advantage of this formulation was that the producing, processing, distributing, and consuming sectors were tied together and a computational algorithm existed which could then be used to obtain directly and efficiently the optimum competitive price and allocation solution. Due to limited computational capabilities, however, further simplifications on the supply side of the model may be necessary to obtain solutions. Nevertheless, considerable additional information as to the quality of the production data and knowledge of demand relations may be gained in finalizing this analysis.

West and Brandow[46] constructed a model which estimated competitive equilibrium patterns of milk production, consumption, prices, and shipments for the Northeastern and North Central states, assuming the removal of institutional barriers. These patterns were then compared with actual 1960 conditions. They obtained the estimates by using an iterative procedure of establishing product prices, solving the demand and supply functions for quantities produced and consumed, allocating

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[46] Donald A. West and George E. Brandow, "Space-Product Equilibrium in the Dairy Industry of the Northeastern and North Central Regions," Journal of Farm Economics, XLVI (November, 1964), pp. 719-731.

these quantities, and adjusting prices. This procedure was repeated until all equilibrium conditions were met.

An interesting aspect of their analysis was the hypothesizing of a fixed price differential between Grade A and manufacturing grade milk.

West and Brandow hypothesized a constant g-factor to represent the price differential between Grade A and Grade B milk in a specific area when both grades are produced in that area. The g-factor was actually defined as the cost of meeting the additional sanitary requirements for fluid products in dollars per 100 pounds of milk. A realistic differential was judged by them to be $.35 per 100 pounds of milk. This differential was applied uniformly to all regions.

In reality, however, West and Brandow felt that, due to the effect of institutional factors and unreasonable sanitary regulations, the price differential in most regions has been on the average much greater than this $.35 uniform value. Thus, the effect of these factors has been to maintain prices of milk for fluid use well above prices of milk for manufacturing and to allow the production of fluid quality milk to exceed its consumption. Rigid sanitary regulations do raise the cost of producing Grade A milk, and institutional restraints can increase the cost of entering a market so it is quite possible that the Grade A - Grade B price differential is higher than necessary. Therefore, West and Brandow said that in the absence of these more rigid institutional and sanitary barriers, the price differential between Grade A and Grade B would approximate the uniform $.35 cost differential hypothesized. As it stands now, they felt the diversion of surplus Grade A milk to

manufacturing uses was an inefficient use of resources, ceteris paribus.[47]

West listed four types of institutional factors that he felt were effective in the dairy sector. They are the presence of large milk producers' cooperatives, governmental marketing and pricing regulations, sanitary regulations, and trucking regulations.[48]

Each and every one of these factors West pointed out as contributing significantly to the mis-allocation of agricultural resources in the dairy industry generally through restricting the movement of milk between markets.

The solution he presented was to remove these institutional barriers and to rely more heavily on a sterile concentrated milk to assure an adequate supply of whole milk at reasonable prices. The fact is that these institutional factors seem to be favored by both the public and the dairy industry. Also, there is no clear evidence that the dairy industry can do without them. In addition, the fact is that the development and marketing of a sterile concentrated milk is not progressing rapidly, so it is not likely to be a significant factor in the near future. Thus, the existing pricing problem of fluid milk still remains to be solved.

The logical consistency with which West used the constant g-factor in his model seemed to hold, but some reflections may be

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[47] Donald A. West, "Equilibrium Prices and Product Shipments in the Dairy Industry of the Northeastern and North Central Regions." Unpublished Ph. D. thesis, The Pennsylvania State University, University Park, Pennsylvania, 1963, p. 4.

[48] Ibid., p. 12.

appropriate.

As was mentioned above, the constant g-factor was based on the cost of production differential between Grade A and Grade B milk. Thus, once one knew the Grade A price, the Grade B price was set \$.35 below the Grade A price. In other words, the Grade B price was expressed in terms of the Grade A price. There was only one supply function for each area. The cost of production was assumed to be the same between Grade A and Grade B in a specific area, and uniform for all regions. The Grade B price was determined by the Grade A price, the difference being the constant g-factor. There seems to be no logical reason why the regional variation in Grade A prices should be related directly to the cost of transfering fluid milk while the Grade B price in all regions is rigidly held to a constant production cost differential relative to the Grade A price. If this is accepted, then the constant Grade A - Grade B price differential used by West and Brandow must be abandoned, and the two prices must be permitted to vary independently.

This brings forth the concept of a variable g-factor rather than a constant g-factor for each area. Using both fluid and manufacturing transfer costs and a variable g-factor between Grade A and Grade B milk seems more realistic. It seems likely that the cost of production between Grade A and Grade B milk varies between regions.

Another point that appeared in West's solution of his model was the location of Grade B producing regions using the constant g-factor. Comparing the actual conditions existing in 1960 and the solutions to West's model, it appeared that the number of Grade B producing regions in 1960 would be greatly reduced, with Grade B production highly

concentrated in the Midwest and Lake States. This was a direct result of the constant g-factor used by West. The constant Grade A - Grade B price differential must be maintained in all regions producing both grades of milk. But it can be maintained only if no two Grade B producing regions exchange both fluid milk and manufactured products. West eliminated the possibility of such exchanges among the Grade B producing regions with his technique for determining the quantities of Grade A and Grade B milk produced in each region.[49] The result was that only those regions with the greatest surplus were designated to be Grade B producing regions. Thus, each Grade B producing region needed no manufactured products from other regions, and the difference in Grade B price was exactly equal to the difference in Grade A price in the same region. Using a variable g-factor would result in a more dispersed production pattern for Grade B. This would conform much more closely to the real world where Grade A - Grade B price differentials do vary, and Grade B milk is produced in many areas.

Several of these points need to be tested, especially the variable g-factor. It appears to be quite realistic if we accept that the costs of production for Grade A and Grade B milk do vary from area to area.

In regard to economic theory, West and Brandow used a static, partial equilibrium model. They made no effort to explicitly relate

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[49]The technique used was to assume Grade A production equal to 125% of local and export demand for fluid milk. Export demand was allocated to the regions nearest to the deficit regions. Any production over and above the 125% of fluid demand was designated to be Grade B production. Thus, the surplus producing regions most distant from the deficit regions were assumed to produce all the Grade B milk. Ibid., pp. 117-118.

changes in the variables to time. The model was of a partial equilibrium nature since the values of only a few variables were explained. They also assumed perfect competition throughout their analysis.

The branch of economic theory of principal relevance in this report is spatial equilibrium theory. The basis of spatial equilibrium theory, of course, are the principles of product equilibrium and location theory. These principles were explained in an abundance of literature and will not be discussed here.

One workable framework for a spatial equilibrium model was developed by Samuelson.[50] The key to his approach was casting the equilibrium problem in terms of a maximization procedure.

West used the Samuelson formulation as applied to an n-region, one product case, generalized by Samuelson in his article.[51] The use of Samuelson's concept of net social payoff proves quite versatile in the construction of a spatial equilibrium model, but it may by no means be the best method.

There appear to be four possible ways to improve the model and its testing as compared to the West-Brandow approach:

(1) Possibly a dynamic model incorporating time and time lags into the spatial approach would aid in predicting the consequences of changes made in policies. Recursive supply functions would be one example where this could be done.

(2) Another possible way of improving the model used by West

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[50] Samuelson, op. cit., pp. 283-303.

[51] Ibid., pp. 291-292.

and Brandow is to incorporate a variable g-factor rather than a constant g-factor. Cost of production would seem to vary between Grade A and Grade B by regions, thus this needs further testing.

(3) A third possible improvement is to derive two supply functions for each area rather than a single one as West and Brandow did. West and Brandow wrote the area supply function as a single linear equation expressed in terms of only the Grade A price. The assumption of a constant g-factor allowed them to do this. Deriving separate supply functions for both Grade A and Grade B milk for each area seems more concise.

(4) The final possibility is in regard to the solving of the model. West and Brandow did not use a computer for their analysis but rather used a desk calculator and other manual manipulations. Takayama and Judge[52] showed how to convert the Samuelson formulation into a quadratic programming problem, and thus made it possible to solve by computer analysis. With the modern computing facilities and the techniques supplied by Takayama and Judge and others in recent articles, one should be able to derive quite accurate and hopefully precise solutions, having added the three previous improvements.

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[52] T. Takayama and G. G. Judge, "Spatial Equilibrium and Quadratic Programming," Journal of Farm Economics, XLVI (February, 1964), pp. 67-93.

POLICY APPLICATION OF SPATIAL MODELS

Spatial equilibrium models have considerable appeal in that they include significant elements such as demand functions, supply functions, and transport costs which are theoretically required for solving inter-regional pricing and trade problems at the industry level.

The stability of trading patterns and price differentials for a given commodity from year to year depends on such factors as transport costs relative to commodity price, the elasticities of supply and demand, and the size of the net trade of each region relative to its total production and consumption of the commodity. Spatial equilibrium models should be useful in understanding the price and trade pattern of any farm product given the above information.

Conceptually, the spatial equilibrium model is one of wide applicability. It is not excessively difficult to manipulate. Probably the most serious limitation upon its use is independent of the model as such and that is the difficulty of estimating and determining the individual demand and supply or cost functions--an empirical problem.

A useful purpose this type of model may have to the dairy industry is to suggest an efficient supply control scheme. Information relevant to this purpose would be of prime interest to the farm supply industry, farm commodity marketing firms, farmers, bankers, and policy makers at all levels of government. If a supply control scheme were adopted by the Federal Order program, this model might be useful in suggesting where production restrictions should be relaxed first, if additional

output is desired at lowest cost.

Changes in consumer demands are also relevant in this context. As consumers become more affluent, as they change their work and consumption habits, and as their location and composition change, the amount of milk consumed, at given prices, also changes. Furthermore, new products are being developed in the market, some being complements and others substitutes. All of these have important effects on the demand for milk, and hence on milk prices.

In addition to changes in policies applicable to other farm products, import and export policies for dairy products have a direct impact on the results of domestic policies adapted for the dairy industry. These policies change from time to time and the impact of such changes on domestic dairy programs needs to be considered.

Until recently, milk prices remained fairly constant during a period when prices of production inputs increased rather steadily. This situation was a factor contributing to the apparent unrest in the dairy industry and the dissatisfaction with the price and income situation in the industry. Evidence of dissatisfaction may be indicated by the recent pressure for and changes in the prices established in federal milk marketing orders. Changes have been made in the level of milk prices, elimination of seasonal pricing, and changes in the supply-demand adjustors of milk prices. These changes were effectuated as a result of the decline in milk production at the national level and problems created by improper price alignments between interdependent geographic markets.

In an attempt to enhance dairy farm incomes, there has been a concerted effort to form strong regional federations of milk producer

cooperative associations. These federations have been formed in an attempt to eliminate disruptive marketing practices among cooperatives, to develop a common voice on policy, to develop uniform proposals and support regarding market regulation and prices. At the same time, producers are attempting to attain a better position to bargain with buyers of regional or national milk processing concerns. They feel a need to be better able to follow the demand for raw milk as the accounts of large retailers shift from one processor to another whose location may be outside their local marketing area.

All of these factors and changes have an important influence upon the results of various price and income policies for the dairy industry. In an attempt to obtain more favorable economic climate in which to adjust to changes in the industry and in the economy, organizations will undoubtedly propose many and varied types of alternative price and income policies and programs which need to be objectively analyzed and evaluated in order to provide the necessary information required for policy decisions. Applying the spatial equilibrium model to the dairy industry, therefore, may be quite useful if the predictions derived from the model are accurate and precise.

No doubt any equilibrium involves oversimplifications, but this does not make the model inconsistent or non-operational. However, it may be worthwhile to consider possible extensions of the model in order to incorporate more of the significant factors in the real economy. One type of extension suggested in the literature is to incorporate time lags and supply responses to provide a dynamic rather than a static equilibrium model.

Whether spatial equilibrium models will prove sufficiently accurate and inexpensive for use in the practical forecasting of prices, price differentials, and commodity movements remains to be seen. It is the research worker's task to alleviate this uncertainty.

While the solutions derived from these models must be modified in their use for policy analysis, they nevertheless provide better insights than can be obtained from informal and nonquantitative analyses and speculation based on other models which are also inadequate.

SUMMARY

General concern is exhibited in the United States in regard to the present agricultural policies. Taxpayers are concerned about the expense of support programs while farmers elicit concern over the inequity of their income and the instability of farm commodity prices.

In the dairy industry in particular, questions concerning the allocation of resources, farm prices, and hence farm incomes, have arisen time and again over the past decade or more. Since the problem in one facet is an economic one, economists have been involved.

Economists have faced a continuing challenge to develop models or analytical devices useful in analyzing changes made in policies, whether in the public or private sector. One method that has been used in constructing and testing a model is spatial equilibrium analysis.

In using spatial equilibrium methodology several issues and problems are confronted which must be recognized and alleviated. The issues of positive and normative models, aggregation, defining the objective function, and so on, are all a part of dealing with spatial equilibrium models.

Of particular importance is the need for a model in the dairy industry that can predict accurately what the consequences of change in government policy will be. At the present time, no analytical device can confidently be used in this manner.

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AN EVALUATION OF SPATIAL EQUILIBRIUM MODELS FOR POLICY DECISIONS IN THE DAIRY INDUSTRY

by

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General concern about agricultural policies exists in the United States because of the economic problems and instability that are present. This situation has arisen because these policies have a definite impact upon the level of production, stability of agricultural prices, equity of incomes for farmers, and the expense to taxpayers. A clear understanding of the laws of price equilibrium and supply response is necessary if American agriculture is to operate in the public interest.

In the dairy industry specifically, inequity of farmer's incomes and instability of milk prices have exerted a great amount of pressure upon the policy makers to re-evaluate the programs and their method of operation. The central problem is that location theory does not adequately explain the tremendous buildup of Grade A milk supplies and the resulting surplus problem. Policy makers are in need of an analytical device which will reliably depict the impact of any changes made in farm policies, both at the national level and the regional market level.

The purpose of this work is to appraise the technique of spatial equilibrium analysis as a useful econometric device for policy planning, and to develop extensions of relevant models in order to improve their usefulness in analyzing the impact of changes made in agricultural policies.

Spatial equilibrium theory has gradually developed from the principles of product equilibrium and location theory. Location theory has advanced from the earliest attempts to analyze the effects of space on economic activity by use of an isolated city-state to the more general system of analysis of spatial interdependence. Product equilibrium has progressed from the purely conceptual framework to an operational

formulation used in empirical analysis to solve complex problems.

Conceptual and empirical issues and problems are faced when utilizing this methodology in construction of a model. A research worker is handicapped by such issues as positive versus normative models, the assumption of pure competition, defining an appropriate objective function, uncertainty, the aggregation problem, and the data problem. Each of these issues has to be weighed in one's analysis.

Contributions to the theory of spatial equilibrium can basically be analyzed from the standpoint of pure construct as well as from the standpoint of empirically testable models. Several empirical studies have contributed heavily to the theory of spatial equilibrium, especially in the area of alleviating to a degree the conceptual and empirical problems mentioned above.

Extensions of spatial equilibrium models are important in aiding the usefulness of these models for policy analysis. Among the possible extensions available is the use of recursive supply functions incorporating time and time lags into a dynamic analysis.

Spatial equilibrium models have considerable appeal in that they include significant elements such as demand functions, supply functions, and transport costs which are theoretically required for solving interregional pricing and trade problems at the national and regional level. The spatial equilibrium model is one of wide applicability and is not excessively difficult to manipulate.

In the dairy industry spatial equilibrium analysis can be used to reflect supply response conditions at the producer level and demand conditions at the consumer level. The impact of import and export

policies can also be analyzed.

While the solutions derived from these models may have to be modified for use in policy analysis, they nevertheless should provide better insights into problems than can be obtained from informal analyses based on other models which are inadequate.